CHAPTER 5

CELL CYCLE

MULTIPLE CHOICE QUESTIONS

1. **The series of events from the time a cell is produced until it completes mitosis and produces new cells:**

   (a) Meiosis (b) Interphase (c) Cell cycle (d) Cytokinesis

2. **Who discovered mitosis?**

   (a) Walter Flemming (b) Oscar Hertwig
   (c) T. H. Morgan (d) August Weismann

3. **The division of cytoplasm:**

   (a) Karyokinesis (b) Cytokinesis (c) Prophase (d) Metaphase

4. **The division of nucleus:**

   (a) Cell cycle (b) Mitosis (c) Meiosis (d) Karyokinesis

5. **Which animal shows budding?**

   (a) *Amoeba* (b) *Paramecium* (c) Sea star (d) Hydra

6. **Which animal shows regeneration?**

   (a) *Amoeba* (b) *Paramecium* (c) Sea star (d) Hydra

7. **The phenomenon of spreading the disease:**

   (a) Benign tumor (b) Tumor (c) Metastasis (d) Budding

8. **Who discovered meiosis?**

   (a) Walter Flemming (b) Oscar Hertwig (c) August Weismann (d) T. H. Morgan

9. **In meiosis, one diploid cell divides into how many haploid cells?**

   (a) 2 (b) 4 (c) 6 (d) 8

10. **In which phase of meiosis I the pairs of homologous chromosomes align along equatorial plane forming the metaphase plate?**

    (a) Prophase I (b) Metaphase I (c) Anaphase I (d) Telophase I

11. **The process in which homologous chromosomes line up with each other and form pairs:**

    (a) Tetrad (b) Crossing over (c) Chiasmata (d) Synapsis

12. **Who discovered crossing over?**

    (a) Walter Flemming (b) Oscar Hertwig
    (c) August Weismann (d) T. H. Morgan

13. **The two non-sister chromatids of homologous chromosomes join each other at:**

    (a) Tetrad (b) Crossing over (c) Chiasmata (d) Bivalent

14. August Weismann described the significance of meiosis for reproduction and inheritance in:

(a) 1890 (b) 1891 (c) 1892 (d) 1893

15. The abnormal separation of homologous chromosomes during anaphaseI of meiosisI:

(a) Disjunction (b) Non-disjunction (c) Synapsis (d) None of these

16. The programmed cell death:

(a) Necrosis (b) Apoptosis (c) Endocytosis (d) Exocytosis

17. The accidental cell death:

(a) Phagocytosis (b) Apoptosis (c) Both a & b (d) Necrosis

18. Blebs break off from the cell and are called:

(a) Apoptotic bodies (b) Lysosomes (c) Both a & b (d) None of these

ANSWERS:

1	c	2	a	3	b	4	d	5	d
6	c	7	c	8	b	9	b	10	b
11	d	12	d	13	c	14	a	15	b
16	b	17	d	18	a				

SHORT QUESTIONS

Q. No. 1 Define reproduction.

REPRODUCTION

The process through which living organisms produce offsprings of their own kind is called reproduction.

Q. No. 2 Which one is the most basic characteristic of life.

BASIC CHARACTERISTIC OF LIFE

The most basic characteristic of life is reproduction.

Q. No. 3 At what levels of organization does reproduction occur?

LEVELS OF ORGANIZATION AT WHICH REPRODUCTION OCCURS

Reproduction occurs at different levels of organization.

- Parts of cell, such as chromosomes produce new chromosomes.
- Cells produce new cells.
- Individuals produce offsprings like themselves.

Q. No. 4 How much time interphase lasts of the total time of cell cycle?

DURATION OF INTERPHASE

Interphase lasts for at least 90% of the total time required for the cell cycle.

Q. No. 5 Why cell cycle can not be reversed?

REVERSAL OF CELL CYCLE

The events of cell-cycle are ordered & directional. i.e. each event occurs in a sequential fashion and it is impossible to 'reverse' the cycle.

Q. No. 6 What is the difference between somatic and germ line cells?

DIFFERENCE BETWEEN SOMATIC AND GERM LINE CELLS

Somatic cells form the body of organisms while germ line cells give rise to gametes. Somatic cells undergo mitosis and germ cells undergo meiosis.

Q. No. 7 Why the cell division of prokaryotes is not called mitosis?

CELL DIVISION OF PROKARYOTES

The cell division of prokaryotes is not called mitosis because prokaryotes do not have proper nucleus and do not form spindle fibres during division.

Q. No. 8 From where the word meiosis has been derived? What does it mean?

DERIVATION OF MEIOSIS

The word 'meiosis' comes from the Greek word 'meioun' which means 'to make smaller'. Meiosis results in a reduction in chromosome number.

Q. No. 9 What is the contribution of Thomas Hunt Morgan?

CONTRIBUTION OF THOMAS HUNT MORGAN

In 1911, the American geneticist Thomas Hunt Morgan observed the phenomenon of crossing over in fruit fly *Drosophila melanogaster*.

Q. No. 10 How many cells die each day by apoptosis in an adult human?

DEATH RATE OF CELLS BY APOPTOSIS

In an adult human, 50 to 70 billion cells die each day by apoptosis.

Q. No. 11 Nucleus is only visible in interphase while chromosomes are only visible in cell division stage. Why is that?

VISIBILITY OF NUCLEUS AND CHROMOSOMES

Nuclear membrane breaks during cell division so there is no distinct nucleus. In interphase nuclear material is in the form of fine chromatin which condenses during prophase to get into the shape of chromosomes.

Q. No. 12 During crossing over, is genetic material exchanged between sister/non-sister chromatids of homologous/non-homologous chromosomes?

Non-sister chromatids of homologous chromosomes.

Q. No. 13 What is the difference between diploid and haploid?

DIPLOID CELLS

These are the cells in which chromosomes are in pairs (Homologous pairs).

HAPLOID CELLS

These are the cells in which chromosomes are half in number, and thus are not in the form of pairs.

LONG QUESTIONS

Q. No. 1 Write a note on cell cycle.

CELL CYCLE

Definition:

The series of events from the time a cell is produced until it completes mitosis and produces new cells is called cell cycle.

MAJOR PHASES OF CELL CYCLE

Cell cycle consists of two major phases:

1. Interphase
2. Mitotic Phase (M Phase)

1. Interphase

Interphase is the time when a cell prepares itself for division. It is characterized by a high metabolic activity, and it performs various functions.

Phases of Interphase:

It is divided into three phases:

i. G1 phase (First gap)
ii. S phase (Synthesis phase)
iii. G2 phase (Second gap)

i. G1 Phase:

This is called as the First Gap. After its production, a cell starts its cell cycle in G1 phase.

Events:

- Cell increases its supply of proteins.
- Cell increases the number of its organelles (mitochondria, ribosomes)
- Cell grows in size.
- Synthesis of various enzymes required in the S Phase, for the duplication of chromosomes.

Duration:

Typically, the Inter phase lasts for at least 90% of the total time required for the cell cycle.

ii. S Phase:

This phase is the Synthesis Phase.

Event:

- Cell duplicates its chromosomes as a result, each chromosome consists of two sister chromatids.

Iii. G2 Phase: This phase is called as the Second Gap.

Event:

- Cell prepares proteins that are essential for mitosis, mainly for the production of spindle fibers.

Inhibition of Protein Synthesis:

Inhibition of protein synthesis during G2 phase prevents cell from undergoing mitosis.

2. M Phase

After the G2 phase of Inter phase, the cell enters the division phase, i.e. M Phase. It is characterized by mitosis, in which cell divides into the two daughter cells.

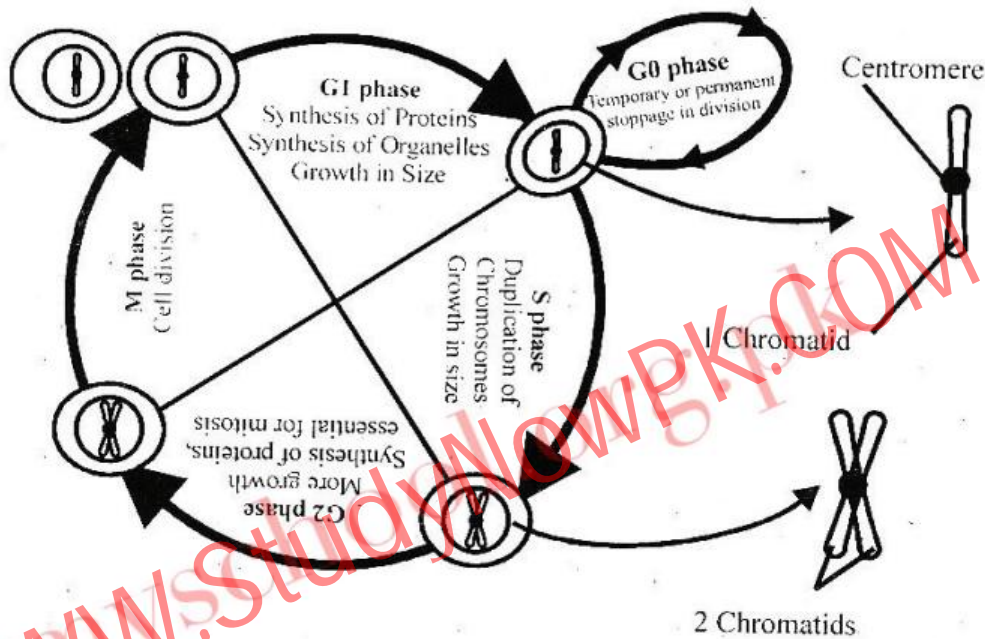



Figure: The Eukaryotic Cell Cycle

G0 Phase: In multicellular eukaryotes, cells enter G0 phase from G1 and stop dividing.

Permanent G0 Phase: Some cells remain in G0 phase for an indefinite period of time.
Example: Neurons

Semi-permanent G0 Phase: Some cells enter G0 phase semi-permanently.
Example: Some cells of liver & kidney

No G0 Phase: Many cells do not enter G0 Phase and continue to divide throughout an organism's life.
Example: Epithelial cells.

Q. No. 2 Write a note on mitosis.

MITOSIS

Discovery:

In 1880s, a German biologist, Walther Flemming observed that in a dividing cell, nucleus passes through a series of changes which he called mitosis.

Definition:

The type of cell division in which a cell divides into two daughter cells, each with the same number of chromosomes as were present in the parent cell is called mitosis.

Occurrence:

- Mitosis occurs only in eukaryotic cells.
- In multicellular organisms, the somatic cells undergo mitosis.

PHASES OF MITOSIS

The process of mitosis is complex and highly regulated. There are two major phases.

i. **Karyokinesis:**
The division of nucleus is called karyokinesis.

ii. **Cytokinesis:**
The division of cytoplasm is called cytokinesis.

KARYOKINESIS

The division of nucleus is further divided into four phases.

i. Prophase
ii. Metaphase
iii. Anaphase
iv. Telophase

i. Prophase:

Condensation of chromatin:

The genetic material in the nucleus is in a loose thread-like form called chromatin. At the onset of prophase, chromatin condenses into highly ordered structures called chromosomes.

Formation of Complete Chromosome:

The genetic material has already been duplicated earlier in S phase, each chromosome is made up of two sister chromatids, bound together at a centromere.

Kinetochore:

Each chromosome has a kinetochore at centromere. Kinetochore is a complex protein structure that is the point where spindle fibers attach.

Movement of Centrosomes:

There are two centrioles, (collectively called a centromere), close to the nucleus. Each centriole duplicates and thus two daughter centrosomes are formed. Both centrosomes migrate to the opposite poles of the cell.

Formation of Mitotic Spindle:

Centrosomes give rise to microtubules by joining tubulin proteins present in cytoplasm. The microtubules thus formed are called spindle fibres. Complete set of spindle fibers is known as the mitotic spindle.

Disappearance of Nuclear Membrane and Nucleoli:

By this time, nucleolus and the nuclear envelope have degraded and the spindle fibers have invaded the central space.

PROPHASE IN PLANT CELLS:

In highly vacuolated plant cells, nucleus has to migrate to the center of the cell before prophase. The cells of plants lack centrioles. So, spindle fibers are formed by the aggregation of tubulin proteins on the surface of nuclear envelope during prophase.

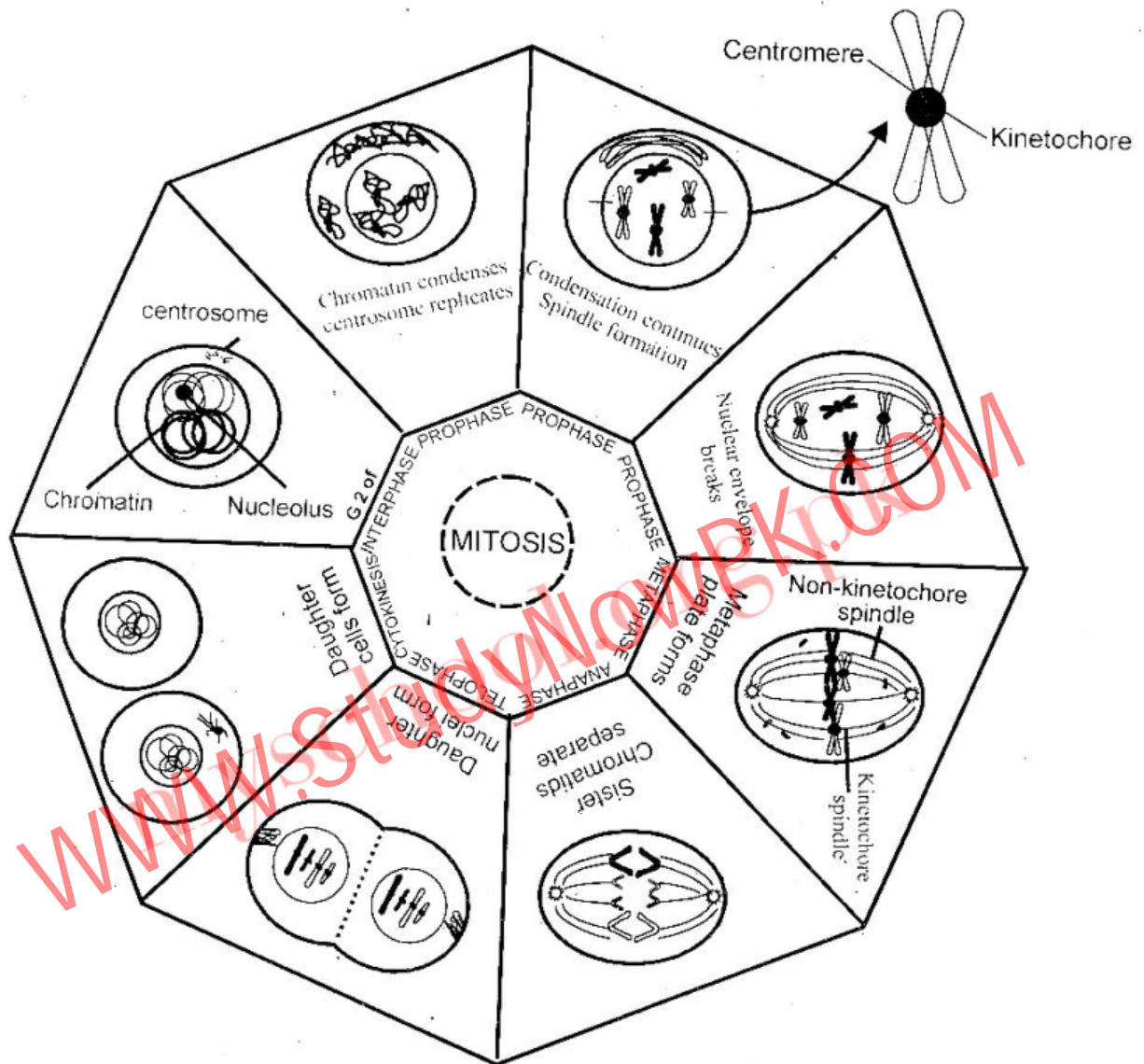



Figure: Stages in Mitosis

ii. **Metaphase:**

Attachment of Kinetochore-fibres:

When spindle fibers have grown to a sufficient length, some spindle fibres known as kinetochore fibres attach with the kinetochores of chromosomes. Two kinetochore fibres from opposite poles attach with each chromosome.

Formation of Metaphase Plate:

Chromosomes arrange themselves along the equator of the cell forming a metaphase plate.

Attachment of Non-Kinetochore fibres:

A number of other fibres (non-kinetochore) from the opposite centrosomes attach with each other.

iii. Anaphase:

Contraction of Kinetochore Fibres:

When a kinetochore spindle fibre connects with the kinetochore of chromosome, it starts to pull toward the originating centrosomes.

Division of Chromatids:

The pulling force divides the chromosome's sister chromatids and they separate. These sister chromatids are now sister-chromosomes, and they are pulled apart toward the respective centrosomes.

Elongation of Non-Kinetochore Fibres:

The other spindle fibres (non-kinetochore) also elongate. At the end of anaphase, cell has succeeded in separating identical copies of chromosomes into two groups at the opposite poles.

iv. Telophase:

Telophase is the reversal of prophase.

Appearance of Nuclear Envelope:

A new nuclear envelope forms around each set of separated chromosomes.

Decondensation of Chromosomes:

Both sets of chromosomes, now surrounded by new nuclear envelopes, unfold back into chromatin. Nuclear division is completed.

CYTOKINESIS

Definition:

The division of cytoplasm is called cytokinesis.

Cytokinesis in Animal Cells:

- In animal cells, cytokinesis occurs by a process known as cleavage.
- A cleavage furrow develops where the metaphase plate used to be.
- The furrow deepens and eventually pinches the parent cell into two daughter cells.

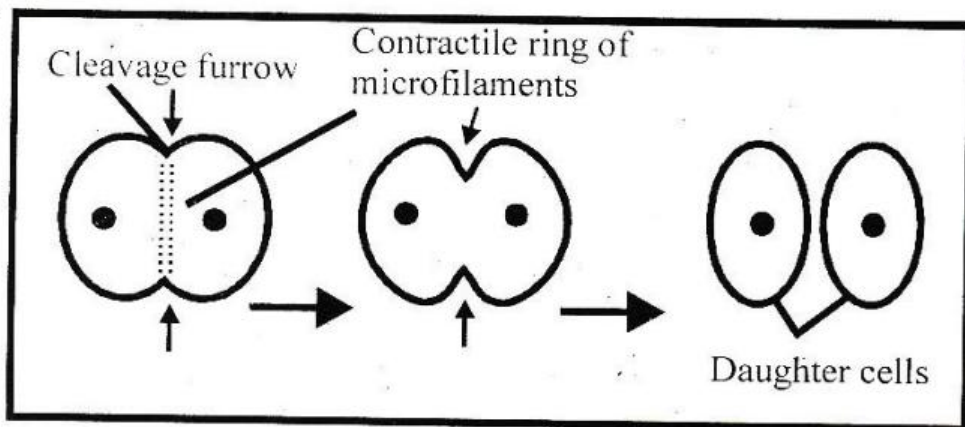



Figure: Cytokinesis in Animal Cell

Cytokinesis in Plant Cells:

- In plant cells, vesicles derived from Golgi apparatus move to the middle of the cell.
- These vesicles fuse to form a membrane-bounded disc which is called cell plate or phragmoplast.
- This plate grows outward and more vesicles fuse with it.
- Finally, the membranes of cell plate fuse with plasma membrane, and its contents join the parental cell wall.
- The result is two daughter cells, each bounded by its own plasma membrane and cell wall.

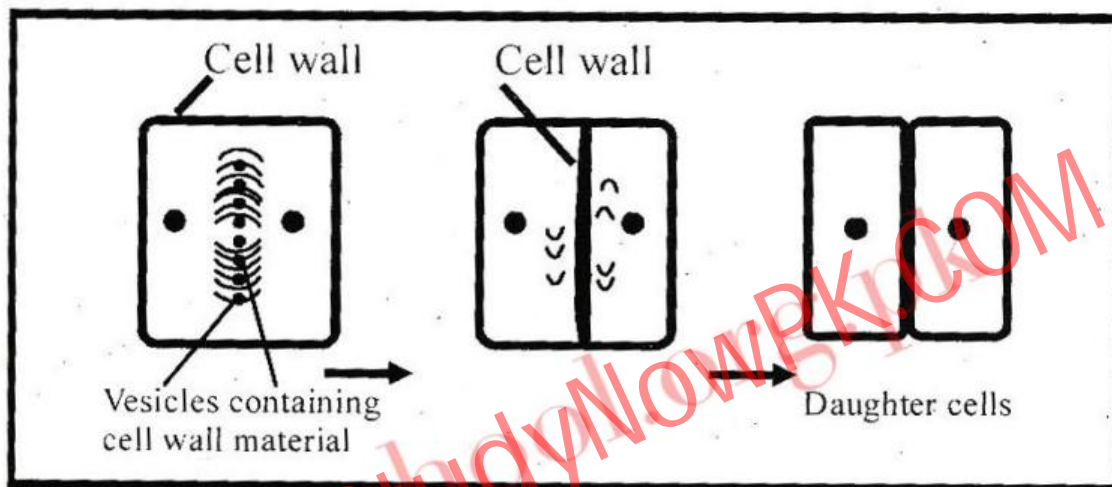



Figure: Cytokinesis in Plant Cell

Q. No. 3 Describe significance of mitosis.

SIGNIFICANCE OF MITOSIS

The importance of mitosis is the maintenance of chromosomal set, i.e. each daughter cell receives chromosomes that are alike in composition and equal in number to the chromosomes of parent cell.

Following are the occasions in the lives of organisms where mitosis happens.

Cell Replacement:

In some body parts, cells are constantly sloughed off and replaced by new ones. New cells are formed by mitosis and are exact copies of the cells being replaced.

Examples: Cells of skin and digestive tract.

Red Blood Cells: Red blood cells have a short life span (about 4 months). New red blood cells are formed by mitosis

Development and Growth:

The number of cells within an organism increase by mitosis. This is the basis of the development of a multicellular body from a single cell, i.e. zygote, and also the basis of growth of multicellular body.

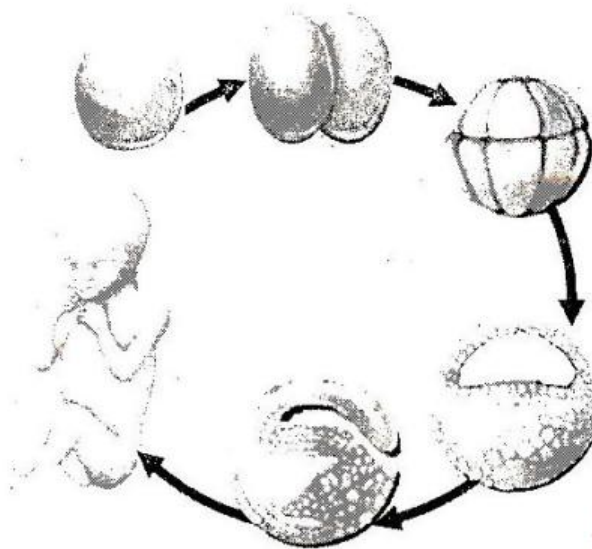
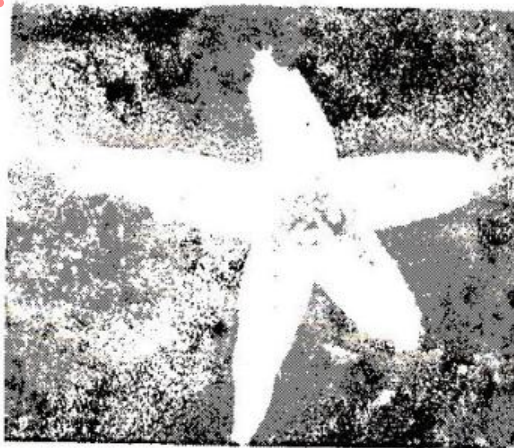



Figure: Development of a single cell (zygote) into a multicellular body

Regeneration:

Some organisms can regenerate parts of their bodies. The production of new cells is achieved by mitosis.

Example:

Sea star regenerates its lost arm through mitosis

Regeneration in Sea Star

Asexual Reproduction:

Some organisms produce genetically similar offsprings through asexual reproduction. Mitosis is a means of asexual reproduction.

Example:

Hydra reproduces asexually by budding. The cells at the surface of hydra undergo mitosis and form a mass called bud. Mitosis continues in the cells of bud and it grows into a new individual.

Vegetative Propagation:

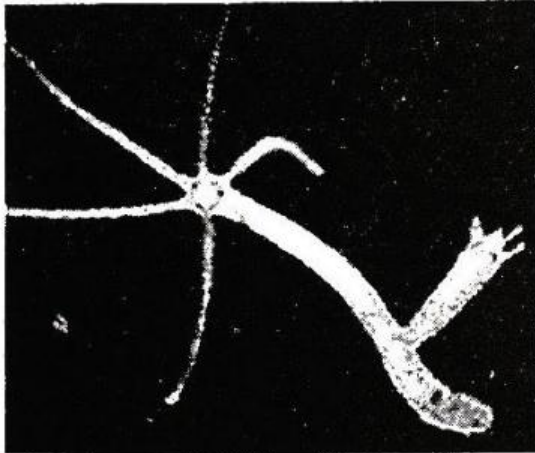
The same division happens during asexual reproduction, i.e. vegetative propagation in plants.

Budding in Hydra **Vegetative Propagation in Plants**

Figure: Asexual Reproduction

Q. No. 4 Describe errors in mitosis.

ERRORS IN MITOSIS

Errors in the control of mitosis may cause cancer.

Tumor Development:

All cells have genes that control the timing and number of mitosis. Sometimes mutations occur in such genes and cells continue to divide. It results in growths of abnormal cells called tumors.

Types of Tumors:

i. **Benign Tumors:**
As long as tumors remain in their original locations, they are called benign tumors.

ii. **Malignant Tumors:**
If tumors start to invade other tissues, they are called malignant or cancerous tumors, and their cells are called cancer cells.

Metastasis:

Malignant tumors can send cancer cells to other body parts where new tumors may form. This phenomenon is called metastasis (spreading of disease).

Q. No. 5 Write a note on meiosis.

MEIOSIS

Definition:

The process by which one diploid (2n) eukaryotic cell divides to generate four haploid (1n) daughter cells is called meiosis.

Discovery:

Meiosis was discovered and described for the first time in 1876, by a German biologist Oscar Hertwig.

PHASES OF MEIOSIS

Interphase:

The preparatory steps of meiosis are identical to the interphase of mitosis. It is divided into the same three phases i.e. G1, S, and G2. Interphase is followed by meiotic divisions Meiosis I and Meiosis II.

MEIOSIS I

In meiosis I, the homologous chromosomes in a diploid cell separate and two haploid daughter cells are produced.

Steps:

Meiosis I occurs in two main steps:

i. Karyokinesis
ii. Cytokinesis

KARYOKINESIS

It is divided into:

i. Prophase I
ii. Metaphase I
iii. Anaphase I
iv. Telophase I

i. Prophase I:

It is the longest phase in meiosis.

Condensation of Chromatin:

During this stage, chromatin condenses into chromosomes.

Synapsis:

The homologous chromosomes line up with each other and form pairs by a process called synapsis.

Bivalent:

Each pair of homologous chromosomes is called bivalent.

Tetrad:

Each bivalent has four chromatids, so it is also called as tetrad

Chiasmata Formation:

The two non-sister chromatids of homologous chromosomes join each other at certain points along their length. These points of attachment are called chiasmata.

Crossing-Over:

The non-sister chromatids of homologous chromosomes exchange their segments. This phenomenon is known as crossing over. After crossing over, each pair of homologous chromosomes remains as a bivalent.

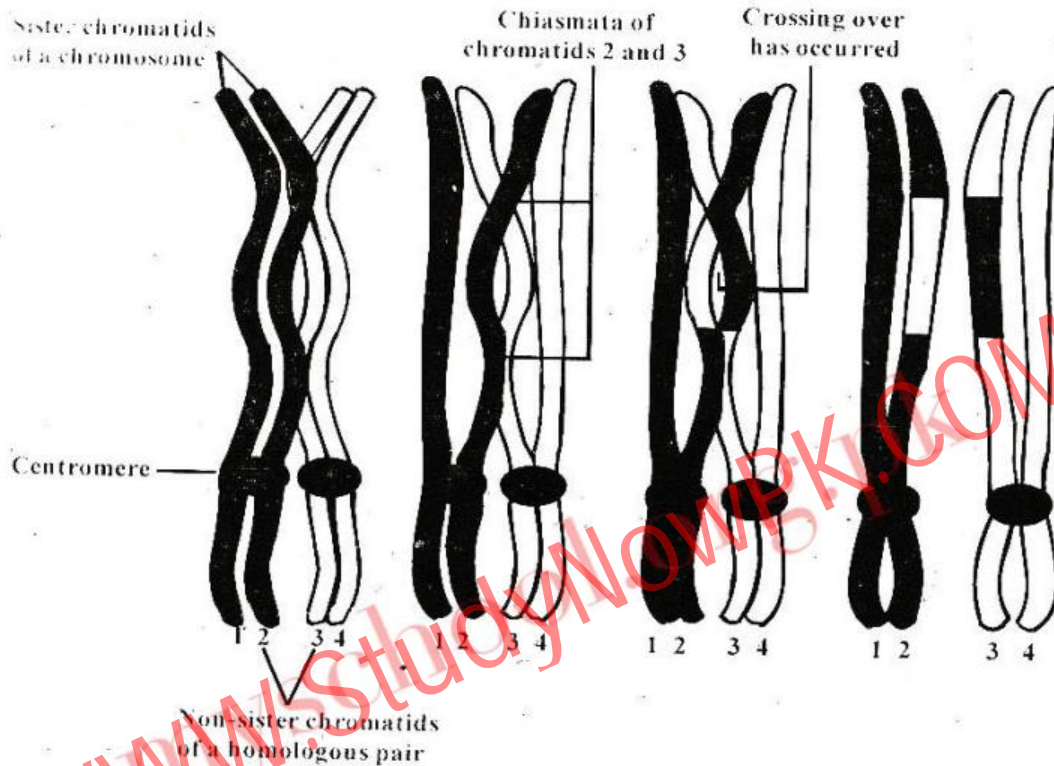



Figure: Crossing Over

Significance of Crossing Over:

The exchange of segments results in the recombination of genetic information.

Nuclear Changes:

Chromosomes condense further, the nucleoli disappear, and the nuclear envelope disintegrates.

Spindle Fibres Formation:

Centrioles, which were duplicated during interphase, migrate to the two poles and give rise to spindle fibres.

Attachment of Kinetochore Fibres:

The kinetochore spindle fibres attach with the kinetochore of chromosomes. While the non-kinetochore spindle fibres from both sides interact with each other. Two kinetochore spindle fibres (from the opposite poles) attach to a pair of chromosomes. In mitosis, two kinetochore spindle fibres attach with one chromosome.

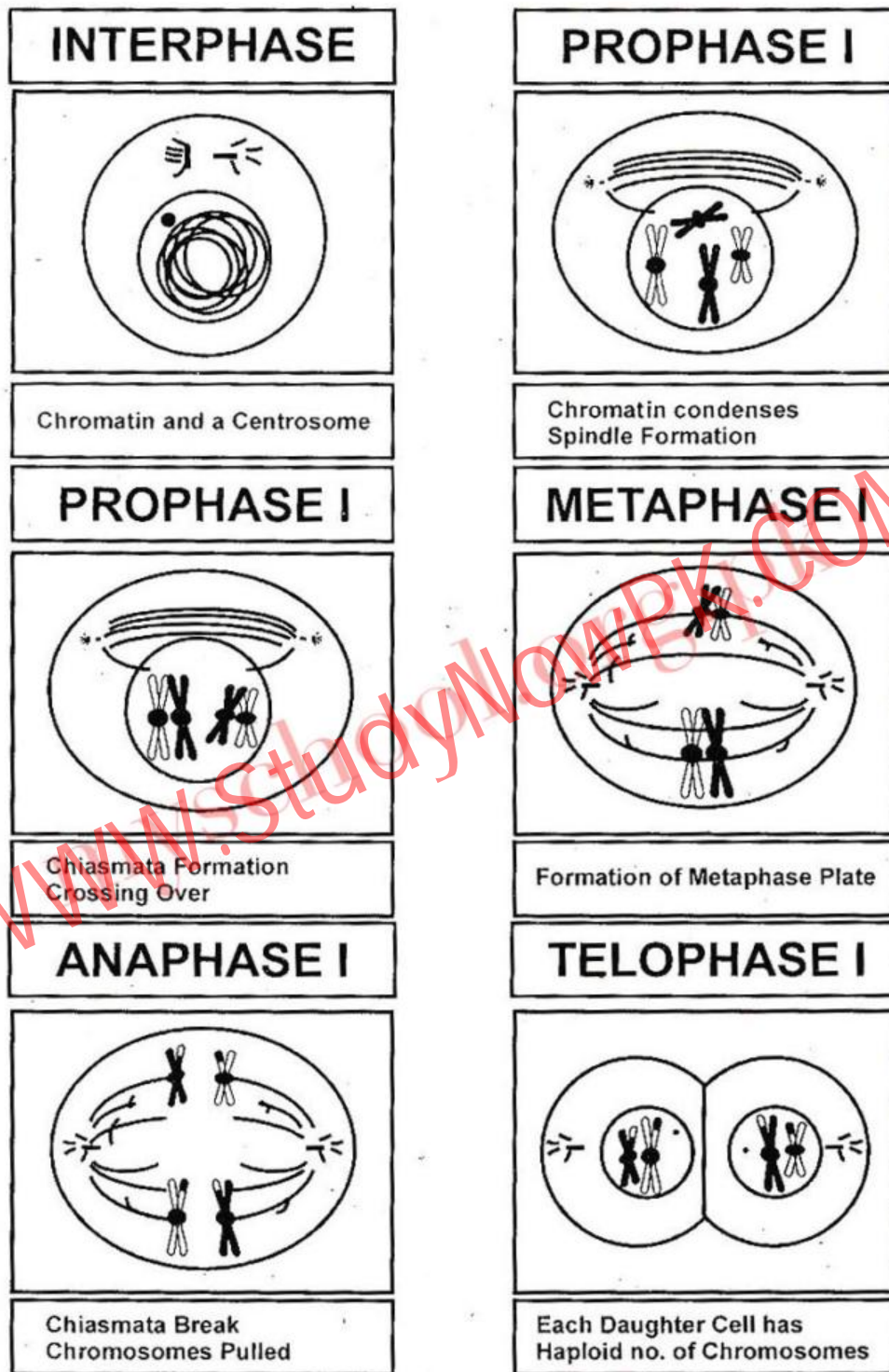



Figure: Stages in Meiosis-I

ii. **Metaphase I:**

Formation of Metaphase-plate

The pairs of homologous chromosomes align along the equatorial plane forming the metaphase plate.

iii. **Anaphase I:**

Separation of Diploid Chromosomes:

Kinetochore spindle fibres shorten. It results in pulling apart the chromosomes of each pair. Since one chromosome is pulled toward one pole, two haploid sets are formed. Each chromosome still contains a pair of sister chromatids.

iv. **Telophase I:**

Chromosomes arrive at the poles. Each pole now has half the number of chromosomes, but each chromosome still consists of two chromatids. Spindle network disappears and nuclear envelope is formed around each set. Chromosomes uncoil back into chromatin.

CYTOKINESIS

Cytokinesis, (the pinching of cell membrane in animal cells or the formation of cell wall in plant cells) occurs and the creation of two haploid daughter cells is completed.

INTERKINESIS OR INTERPHASE II

After meiosis I, both haploid daughter cells enter a period of rest, known as interkinesis or interphase II.

Difference:

The interphase II is different from interphase of mitosis and meiosis I. There is no S Phase and so there is no duplication of chromosomes during this stage.

It is the second part of meiosis, and is similar to mitosis.

MEIOSIS II

Phases of Meiosis II:

It is divided into:

i. Prophase II
ii. Metaphase II
iii. Anaphase II
iv. Telophase II

i. **Prophase II:**

It takes much less time compared to Prophase I. in this prophase , nucleoli and nuclear envelope disappear and chromatin condenses. Centrioles move to the polar regions and make spindle fibres.

ii. **Metaphase II:**

Chromosomes attach with kinetochore spindle fibres and align at the equator of the cell.

iii. **Anaphase II:**

Centromeres are cleaved and sister chromatids are pulled apart. The sister chromatids are now called sister chromosomes, and they are pulled towards opposing poles.

iv. **Telophase II:**

It is marked with uncoiling of chromosomes into chromatin. Nuclear envelopes reforms.

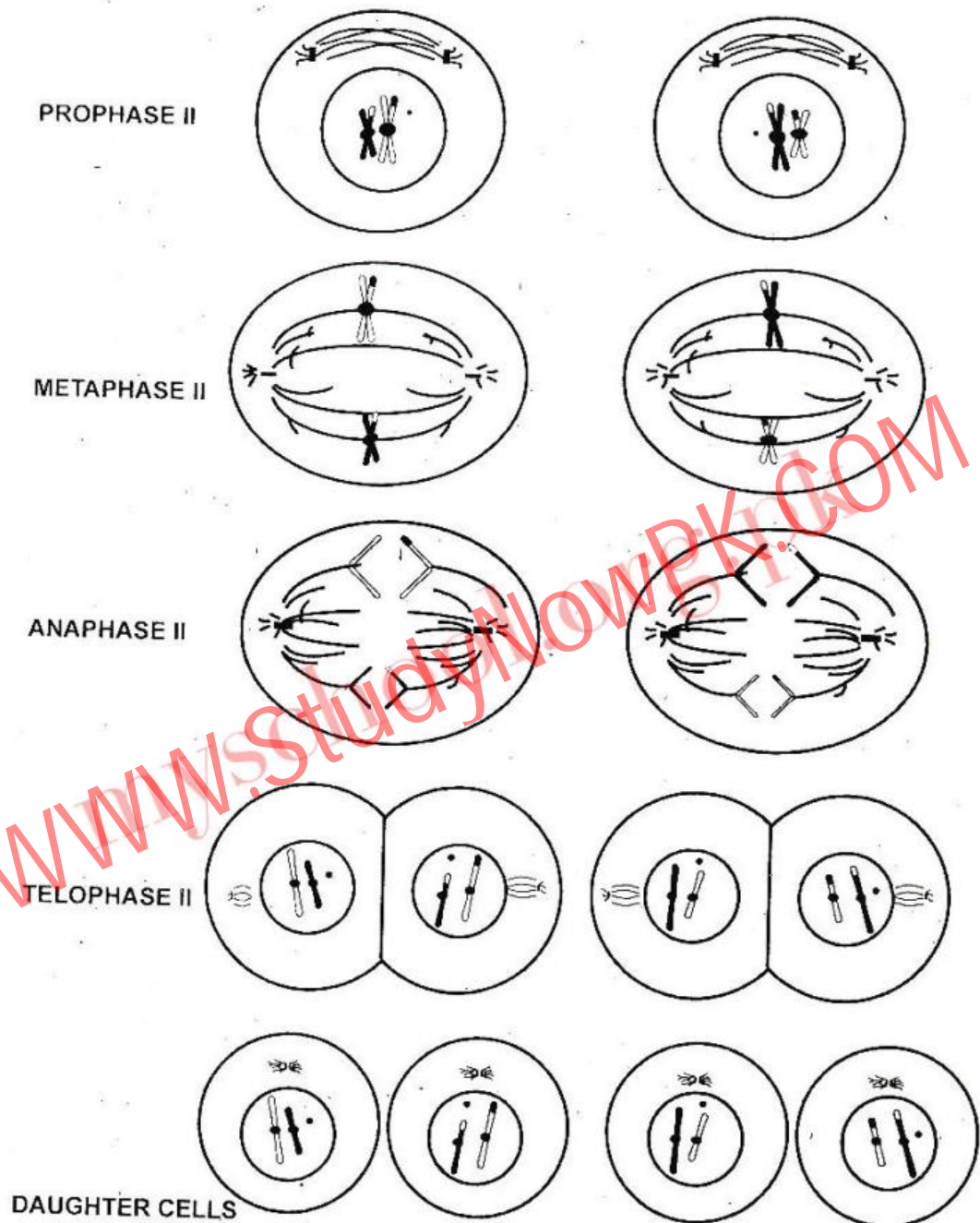



Figure: Stages in Meiosis-II

Cytokinesis:

Cleavage or cell wall formation eventually produces a total of 4 daughter cells, each with a haploid set of chromosomes.

Q. No. 6 Describe significance of meiosis.

SIGNIFICANCE OF MEIOSIS

Role of August Weismann:

The significance of meiosis for reproduction and inheritance was described in 1890 by a German biologist August Weismann. He pointed out that:

'Meiosis was necessary not only to maintain the number of chromosomes in the next generation, but also to produce variations in the next generation.'

Maintenance Of Chromosome Number In Next Generation:

Meiosis is essential for sexual reproduction.

In Humans:

In humans, diploid gamete mother cells or germ line cells undergo meiosis to produce haploid gametes. Male and female gametes unite to form a diploid zygote, which undergoes repeated mitosis and develops into a new human.

Fungi and Protozoans:

Many haploid fungi and protozoans produce haploid gametes through mitosis.

In Plants:

Plants' life cycle shows alternation of generations.

- The cells of diploid sporophyte generation undergo meiosis to produce haploid spores.
- The spores grow into haploid gametophyte generation.
- Gametophyte generation produces haploid gametes through mitosis.
- The gametes combine to produce diploid zygote. Zygote undergoes repeated mitosis to become a diploid sporophyte.

Production Of Variations In Next Generations:

The chromosome pairs of each parent undergo crossing over during meiosis. So daughter cells, i.e gametes, have genetic variations. When gametes fuse to form a zygote, its genetic makeup is different from both the parents. Thus, meiosis allows a species to bring variations in the next generations.

Adaptation:

Beneficial variations help organisms to adapt better to the changes in the environment.

Q. No. 7 Describe errors in meiosis.

ERRORS IN MEIOSIS

Disjunction:

During Anaphase I, chromosomes separate and go to opposite poles, while during anaphase II, sister-chromatids separate. This is called 'Disjunction'.

Non-disjunction:

Sometimes the separation of chromosomes or is not normal and it is called as 'Non-disjunction'.

Consequences of Non-disjunction:

Non-disjunction results in the production of gametes which have either more or less than the normal number of chromosomes. If such an abnormal gamete fuses with a normal gamete, it results in an abnormal number of chromosomes in the next generation, for example 45 or 47 chromosomes in humans.

Q. No. 8 **Give a comparison between mitosis and meiosis.**

COMPARISON BETWEEN MITOSIS & MEIOSIS

MITOSIS	MEIOSIS
PROPHASE Homologous chromosomes do not form pairs. There is no crossing over	**PROPHASE I** Pairing of chromosomes. Crossing over between homologous chromosomes.
METAPHASE Single chromosome align to form metaphase plate.	**METAPHASE I** Homologous pairs align to form metaphase plate.
 ANAPHASE Chromosomes break and individual chromatids are pulled towards poles.	 **ANAPHASE I** Individual chromosomes are pulled towards poles
 DAUGHTER CELLS Daughter nuclei contain diploid number of chromosomes. Each chromosome has single chromatid.	 **DAUGHTER CELLS** Daughter nuclei contain haploid number of chromosomes. Each chromosome has two chromatids.

Q. No. 9 Write a note on apoptosis.

APOPTOSIS

Definition:

The type of cell death which is well-programmed and regulated is called apoptosis.

Rate of Apoptosis:

In an adult human, 50 to 70 billion cells die by apoptosis each day.

MECHANISM

Break Down Of Cytoskeleton:

Cell shrinks and becomes rounded due to the breakdown of cytoskeleton by enzymes.

Degradation of Nucleus:

Chromatin undergoes condensation and nuclear envelope breaks. In this way, nucleus spreads in the form of several discrete chromatin bodies.

Formation of Blebs:

Cell membrane makes irregular buds called blebs.

Formation of Apoptotic Bodies:

Blebs break off from the cell and are now called apoptotic bodies.

Phagocytosis:

These apoptotic bodies are then phagocytosed by other cells.

SIGNIFICANCE OF APOPTOSIS

Cellular Damage and Stress Conditions:

Apoptosis can occur when a cell is damaged or under go stress conditions. Apoptosis removes the damaged cell, preventing it from getting further nutrients.

Infections:

Apoptosis prevents the spread of infection.

Developmental Stages:

Apoptosis also gives advantages during development. For example, during the formation of fingers, the cells between them undergo apoptosis and the digits separate.

Q. No. 10 Write a note on necrosis.

NECROSIS

Definition: The accidental death of cells and living tissues is called necrosis.

Difference from Apoptosis: Necrosis is less sequential than apoptosis.

MECHANISM

Release of Lysosomal Enzymes: During necrosis, there is a release of special enzymes from lysosomes.

Lysis of Cellular Components: Lysosomal enzymes break cellular components and may also be released outside the cell to break the surrounding cell.

Damage to Surrounding Tissues: The cells that die by necrosis may also release harmful chemicals that damage other cells.

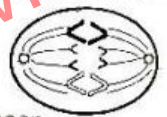
CAUSES OF NECROSIS

There are many causes of necrosis, including:

- Injury
- Infection
- Cancer
- Hypoxic environment
- Lack of proper care to a wound site
- Spider bites

REVIEW QUESTIONS

MULTIPLE CHOICE QUESTIONS

1. **In which stage of the cell cycle each chromosome is duplicated and so it consists of two chromatids?**
   (a) G1 (b) S (c) M (d) G2
2. **If you observe a cell like this one, what phase of mitosis is it?**
   (a) Anaphase (b) Telophase (c) Metaphase (d) Prophase
3. **During which phase of mitosis are spindle fibers formed?**
   (a) G2 (b) Interphase (c) Prophase (d) Metaphase
4. **In which stage of cell cycle, the cell is preparing enzymes for chromosome duplication?**
   (a) G1 (b) G2 (c) S (d) M
5. **Which of the following stage of cell division is very different for animal and plant cells?**
   (a) Metaphase (b) Anaphase (c) Telophase (d) Cytokinesis
6. **Prior to cell division, each chromosome replicates or duplicates its genetic material. The products are connected by centromere and are called:**
   (a) Sister chromosomes (b) Homologous chromosomes
   (c) Non sister chromatids (d) Sister chromatids
7. **The process of mitosis ensures that:**
   (a) Each new cell is genetically different from its parent
   (b) Each new cell receives the proper number of chromosomes
   (c) Cells will divide at the appropriate time
   (d) Chromosomes duplicate without errors
8. **Cytokinesis in a plant cell is characterized by:**
   (a) The equal division of homologous chromosomes
   (b) A pinching off of the cell membrane to divide the cell
   (c) The formation of a cell plate in the cytoplasm
   (d) The movement of chromosomes from the metaphase plate
9. **Which of the following is unique to mitosis and not a part of meiosis I?**
   (a) Homologous chromosomes pair forming bivalents
   (b) Homologous chromosomes cross-over
   (c) Chromosome pairs are broken during anaphase
   (d) Chromatids separate during anaphase

10. Which event distinguishes meiosis from mitosis?

(a) Condensation of chromosomes (b) Loss of nuclear membrane
(c) Formation of metaphase plate (d) Pairing of homologous chromosomes

11. In which stage of the cell cycle most cells spend their lives?

(a) Prophase (b) Metaphase (c) Interphase (d) Telophase

12. Which of the following distinguishes meiosis from mitosis?

(a) The chromosome number is reduced (b) Chromosomes undergo crossing-over
(c) The daughter cells are genetically different from the parent cell
(d) All of the above

13. For mitosis, the chromosome of cell duplicates during interphase. When do the chromosomes duplicate for meiosis?

(a) Before meiosis I (b) Before meiosis II
(c) During meiosis I (d) Do not duplicate

14. Find the correct statement:

(a) Homologous chromosomes form pairs during mitosis
(b) Chromosomes do not duplicate in the interphase preceding meiosis I
(c) Homologous chromosomes form pairs during meiosis but not mitosis
(d) Spindles are not required during meiosis

15. What reason would you suggest for the fact that the total DNA content of each daughter cell is reduced during meiosis?

(a) Chromosomes do not duplicate during the interphase before meiosis I
(b) Chromosomes do not duplicate between meiosis I and II
(c) Half of the chromosomes from each gamete are broken
(d) Sister chromatids separate during anaphase of meiosis I

ANSWER:

1	b	2	a	3	c	4	a	5	d
6	d	7	b	8	c	9	d	10	d
11	c	12	d	13	a	14	c	15	b

UNDERSTANDING THE CONCEPTS

(1) What is cell-cycle and what are its main phases?

Consult Long Question No. 1

(2) The S-phase of interphase is important and a cell can never divide without it. Justify.

IMPORTANCE OF S-PHASE

This part of the interphase is called as the 'Synthesis Phase'

Events of S-Phase:

- Cell duplicates its chromosomes.
- As a result, each chromosome consists of two sister chromatids

Importance of S-Phase:

- This step is characterized by DNA Replication.
- This phase is important because correct duplication is essential for cell division.
- It enables daughter cells to receive the same number of chromosomes as the parent cell. Each daughter cell will have 2n number of chromosomes, which is same as the parent cell.
- If S-phase does not occur, chromosomes and thus DNA, would not duplicate, and the cell would not enter M phase as chromosomes will not consist of sister-chromatids.

(3) **How would you state the events of prophase of mitosis?**

Consult Long Question No. 2

(4) **Make a list of the events of mitosis.**

Consult Long Question No. 2

(5) **How is mitosis significant?**

Consult Long Question No. 3

(6) **Describe the events that occur during the phases of meiosis I?**

Consult Long Question No. 5

(7) **Describe the significance of meiosis.**

Consult Long Question No. 6

(8) **Contrast mitosis and meiosis, emphasizing the events that lead to different outcomes.**

Feature	Mitosis	Meiosis
Definition	The type of cell division in which a cell divides into two daughter cells, each with the same number of chromosomes as were present in the parent cell.	The type of cell division in which one diploid (2n) eukaryotic cell divides to generate four haploid (1n) daughter cells, i.e. with half the number of chromosomes.
Type of cells	It occurs in somatic cells (cells that make up the body)	It occurs in germ cells (gamete producing cells)
Number of divisions	One	Two
Bivalent/tetrad formation	No	Yes
Number of daughter cells	Two	Four
Pairing of homologous chromosomes	No	Yes
Centromere Splitting	During Anaphase	During Anaphase II, and not during I
Crossing over	No	Yes
Variations	Identical genotype as parent cell	Different genotype from parent cell (variations are produced)

EVENTS LEADING TO DIFFERENT OUTCOMES

i. Types of cells
ii. Bivalent formation
iii. Homologous chromosome pairing
iv. Crossing over
v. Number of divisions

(9) Describe necrosis and apoptosis.

Consult Long Questions No. 9 & 10

SHORT QUESTIONS

(1) A nerve cell does not divide after its formation. In which phase of cell-cycle is it?

PHASE OF NERVE CELL

In multicellular eukaryotes, some cells such as nerve cells stop dividing. Such cells that have temporarily or permanently stopped dividing are said to have entered **G0 Phase**.

In case of neurons, the length of G0 phase is indefinite.

(2) How it cytokinesis different in plant cell as compared to an animal cell?

DIFFERENCES IN CYTOKINESIS OF PLANT CELL AND ANIMAL CELL

Feature	Plant Cell Cytokinesis	Animal Cell Cytokinesis
Contributing component	Vesicles from Golgi apparatus	Cell membrane
Dividing structure	Phragmoplast	Cleavage Furrow
Location	At metaphase plate region	In the middle of the cell
Direction	Outward growth of cell-plate	Inward pinching of cell membrane
Involvement of cell wall	Yes	No
Summary of Process	The vesicles fuse to form a cell-plate called 'Phragmoplast' which grows outward and joins the parental cell membrane and cell wall to divide the cell.	The cleavage furrow forms where metaphase plate used to be, and deepens from both sides to pinch and divide the cell.

(3) What type of cell division occurs when our wounds are healed?

CELL DIVISION INVOLVED IN WOUND HEALING

The type of cell division which occurs when our wounds heal is Mitosis. This division occurs in somatic cells, i.e. the cells that form our body. Mitosis ensures a constant number of chromosomes in all the daughter cells and thus make exact genotype complements like the parent cells. Cells multiply in the area and cause closure and healing of the wound.

(4) Plants do not make their gametes by meiosis. How is that?

GAMETES FORMATION IN PLANTS

Although it is a well-known fact that meiosis occurs in germ line cells that produce gametes. However, in the case of plants, it is different. Plants' life cycle shows alternation of generations. There are two generations:

i. **Sporophyte generation:**

It produces spores.

ii. **Gametophyte generation:**

It produces gametes.

- The cells of diploid sporophyte (2n) generation undergo **Meiosis** to produce haploid spores (n).
- The spores grow via mitosis into haploid Gametophyte generation (n).
- Gametophyte generation (n) produces haploid gametes (n) through **Mitosis**.
- The gametes combine to produce diploid zygote (2n), which undergoes repeated mitosis to become a diploid sporophyte (2n).

THE TERMS TO KNOW

Anaphase: The phase of nuclear division in which spindle fibers exert a puling force on the centromere, resulting in separation of sister chromatids.

Apoptosis: Well-programmed, sequenced, and programmed cell death.

Benign: Tumors/lesions which retain their locations and do not invade other organs, i.e do not metastasize

Budding: A form of asexual reproduction seen in hydra which occurs by mitosis

Cell-cycle: The complete life-cycle of a cell

Chiasmata: In homologous chromosomes, the points at which non-sister chromatids join each other.

Crossing-over: The process by which non-sister chromatids of homologous chromosomes exchange their segments

G0 phase: A period characterized by no cell division, also called as 'State of Quiescence'.

G1 phase: A preparatory phase characterized by increase in protein supply, organelle size, cellular size and enzyme synthesis; also called as 'First Gap'

G2 phase: A preparatory phase characterized by synthesis of proteins for spindle-fiber formation; also called as 'Second Gap'.

Homologous chromosomes:

Interphase: A phase characterized by high metabolic activity, in which it prepares itself for division, consisting of G1, S, and G2 phases and lasting for about 90% of cell cycle.

Karyokinesis: The division of nucleus

Kinetochore: A complex protein structure on the centromere, this is the point where spindle fibers attach.

M phase: A phase characterized by cellular division

Malignant: Tumors/lesions which grow uncontrollably and aggressively to invade other organs and lodge more tumor cells, i.e. metastasize to other body parts, and thus become life-threatening

Metaphase: A phase in cellular division characterized by arrangement of chromosomes on the equator and formation of metaphase-plate.

Metaphase plate: An arrangement of chromosomes on the equator, alongwith spindle-fibers.

Mitosis: the type of cell division in which a cell divides into two daughter cells, each with the same number of chromosomes as were present in the parent cell.

Necrosis: Accidental and poorly sequential cell death.

Non-sister chromatids: Chromatids of any of the paired (homologous) chromosomes

Phragmoplast: A membrane-bound disc, formed by the Golgi vesicles, which extends to the periphery of a plant cell to fuse with the plasma membrane and cell wall to ultimately divide a cell.

Prophase: A phase in nuclear division characterized by formation of chromosomes and degradation of nuclear envelope.

S phase: A preparatory event of Interphase characterized by replication of cellular DNA or duplication of chromosomes

Sister chromatids: Two identical copies of a chromosome, connected by a centromere

Spindle: Microtubular fibers formed with the help of centrioles during the Prophase of mitotic division.

Synapsis: The process by which homologous chromosomes form pairs with each other during Prophase of meiosis I.

Telophase: The phase in nuclear division characterized by reformation of nuclear envelope and chromatin material.